Research Article

Evaluation of functional outcomes in traumatic spinal cord injury with rehabilitation-acquired urinary tract infections: A retrospective study

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Objective: The objective of this study was to evaluate the impact of urinary tract infections (UTIs) acquired during acute inpatient traumatic Spinal Cord Injury (tSCI) rehabilitation on Functional Independence Measure (FIM) gains.
Design: Retrospective chart review of consecutive patients with tSCI admitted to an acute rehabilitation facility from 2007–2012. The primary outcome was FIM scores and the association with UTI.
Results: The sample included 110 patients and 70 acquired UTIs. No demographic differences were observed between groups with and without UTI. Those with UTIs had significantly lower FIM motor scores, on admission, discharge, and gain, as well as lower FIM efficiency and longer lengths of stay compared to those without a UTI. Recurrence of UTI was associated with increased length of stay, but did not impact FIM motor gains.
Conclusions: There was a statistically significant correlation between acquired UTIs and lower FIM motor scores on admission, gain, and discharge in tSCI rehabilitation. The correlation of UTI and decreased FIM gains are similar to other neurorehabilitation populations with UTI occurrence. UTIs are an important negative variable when measuring functional outcomes in rehabilitation. Further prospective studies should be performed to investigate this correlation.

Keywords: Urinary Tract Infections, Spinal cord injuries, Neurological rehabilitation, Treatment outcome

Introduction

In the United States, there are approximately 17,000 new cases of traumatic spinal cord injury annually, leading to devastating impairments of the motor, sensory, and autonomic nervous systems.[1] Adverse events resulting in significant morbidity are exceedingly common in the acute phase of spinal cord injury (SCI), occurring in more than 77% of patients, with urinary tract infections (UTIs) compromising nearly one third of all adverse events.[2] Similarly, others have reported that 22% of patients with acute SCI develop UTIs during the first 50 days of injury.[3–8] Several factors contribute to the increased risk of UTI in neurogenic bladder including impaired voiding and catheter use.[8]

Many of these adverse events occur during the acute inpatient rehabilitation of SCI. Studies in other neurorehabilitation populations have demonstrated decreased functional outcomes in association with acquired UTIs. In acute ischemic stroke, UTIs were independently associated with inferior clinical outcomes at 3 months.[9] In severe TBI, the presence of a UTI during inpatient rehabilitation was predictive of worse mobility.[10] This population also had lower Functional Independence Measure (FIM) scores at 1 year associated with UTI during inpatient rehabilitation.[11] Even in the subacute rehabilitation setting including all etiologies for rehabilitation admission, those that develop a UTI had a lower discharge FIM score and were more likely to require residential care or community services.[12]

There is limited literature on the association of rehabilitation-acquired UTIs and the functional outcomes during inpatient rehabilitation of tSCI. Abdul-Sattar performed a prospective study of 90 consecutive tSCI patients admitted for inpatient rehabilitation in Saudi Arabia to identify possible factors influencing FIM motor score outcomes on discharge.[13] He found 70%

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of patients had adverse events in this population, with UTIs occurring the highest, affecting nearly 59% of these patients. There was no statistical association between gain in FIM score and occurrence of UTI. Similar studies have not been performed in patients based in the United States.

The objective of this study was to determine the association, if any, of rehabilitation-acquired urinary tract infections during acute inpatient rehabilitation in traumatic SCI and functional outcomes. We hypothesize that similar associations of diminished functional outcomes seen in the stroke and brain injury populations will be found in the traumatic SCI population.[9–11]

Methods

This retrospective chart review included consecutive accounts with ICD9 diagnoses for traumatic spinal cord injury admitted to a free-standing acute rehabilitation hospital from 2007–2012 for their first inpatient rehabilitation admission. Upper tetraplegia was considered neurologic level C1-4 and lower tetraplegia C5-8. The SCI rehabilitation unit did not support mechanical ventilation, thus this population could not be included in the study. Patients were excluded if their injury was greater than 186 days from admission, defined as chronic according to the European Multicenter Study about Spinal Cord Injury.[14] Patients were also excluded if discharge FIM scores were not performed (i.e. emergent transfer). Occurrences of rehabilitation-acquired UTIs were collected on all patients, excluding admission UTIs being treated with antibiotic. In patients admitted with a UTI, subsequent UTIs were included in the data.

In review of the time period of this study, we identified the use of functional electric stimulation (FES) as a major change in the SCI rehabilitation standard of care and decided to measure this as a possible confounder that could impact FIM scores. We were able to identify those that used FES because FES leg ergometry required a physician order, which was collected from the electronic medical record (EMR) from a generated report.

FIM scores were collected per institution protocol, with scoring occurring within 2 days of admission and discharge for FIM admission and discharge scores, respectively. This study was approved by the hospital institutional review board, conforms to all STROBE guidelines, and reports the required information accordingly (see Supplementary Checklist).

Outcome measures

The primary outcome measures were the change in FIM scores on admission and discharge associated with rehabilitation acquired UTI. Urinary tract infection was defined as treatment with antibiotics of symptoms arising from an infection of the urinary tract, including fever, leukocytosis, worsening spasticity and/or neuropathic pain, malodorous urine with or without sediment, increased leaking between catheterizations, and in those voiding, increased urinary frequency and/or urgency, with urinalysis and culture supporting the diagnosis.[15] Total acquired morbidity, including other infections, fractures, skin wounds, venous thromboembolism (VTE), and unplanned transfers to a higher level of care were also collected. The evaluation of UTI and morbidity was done exclusively by the author's review of clinical documentation. Similar to the UTIs, morbidities were included only if they were acquired or discovered during their rehabilitation admission and documented in the medical records. Secondary outcome measures included the use of FES leg ergometry and associations with morbidity and functional outcome measures.

Data analysis

Descriptive statistics including median, interquartile range, frequency, and percentage were provided for demographic and clinical variables of the population (Table 1) with and without UTI (Table 2). Wilcoxon rank-sum test was used to compare continuous variables between groups and Chi-square test or Fisher's exact test was used for categorical variables. To identify variables that are associated with gain FIM motor, univariate linear regression models was applied to UTI, admission FIM motor, AIS A, tetraplegia, age, sex, FES, and other infections, respectively. Variables with P value less than 0.1 entered the final multivariate linear model (Table 3). Subgroup analyses were performed within UTI group and non-UTI group, and within patients receiving FES and no FES, respectively. Descriptive statistics and P values are provided (Table 4). Finally, subgroup analyses on several variables significantly associated with UTI were performed across recurrence of UTI (Table 5). All analyses were run using SAS 9.4 (SAS Institute Inc, Cary NC).

Results

A total of 188 tSCI accounts were created for admission to the acute inpatient rehabilitation facility. Of these, 118 patients met our eligibility criteria of acute tSCI, and 8 were removed because of missing discharge FIM scores, leaving a final total of 110 patients. There were no significant differences between those that were included and those that were excluded, except for length of stay. Seven of the eight were emergently transferred because of medical instability, none of which were

Table 1 Patient characteristics and clinical outcomes.

	Upper Tetraplegia n = 36	Lower Tetraplegia n = 42	Paraplegia n = 32	
		Median (IQR)		P value†
Age	71 (21.5)	57 (28)	34.5 (37.5)	<.0001
Days Since Injury	13 (11.5)	12 (10)	16.5 (13)	0.0299
Indwelling Catheter Days*	5 (8.72)	7.93 (15.92)	2.66 (6.95)	0.5368
Admission FIM Motor	12 (12.5)	16.5 (12)	26 (8)	<.0001
Admission FIM Cognitive	23 (5.5)	25 (6)	28.5 (4.5)	0.0003
Discharge FIM Motor	50 (43.5)	44 (43)	54.5 (19)	0.2914
Discharge FIM Cognitive	30 (8.5)	30 (6)	33 (4.5)	0.0039
Gain FIM Motor	25 (33.5)	23 (25)	25 (10.5)	0.8180
Gain FIM Cognitive	6 (7)	6 (7)	4.5 (3.5)	0.3610
Gain FIM Total	29.5 (32.5)	27.5 (25)	29 (12)	0.8713
Admission FIM bladder	1 (0)	1 (1)	1 (0)	0.8684
Discharge FIM bladder	5 (6)	5 (6)	5 (2)	0.8333
Change FIM bladder	2 (4)	1.5 (4.5)	2.5 (4)	0.8218
FIM Efficiency	1.25 (1.36)	1.1 (1.61)	0.99 (1.05)	0.9664
Length of Stay (Days)	28.5 (14)	25 (17)	27 (21)	0.7809
		Frequency (%)		P value
UTI	24 (66.67)	26 (61.9)	20 (62.5)	0.8980
Other Infections	8 (22.22)	7 (16.67)	5 (15.63)	0.7406
Pressure Ulcers	2 (5.56)	3 (7.14)	1 (3.13)	0.8744
Venous Thromboembolism	1 (2.78)	2 (4.76)	1 (3.13)	1
Male	24 (66.67)	31 (73.81)	25 (78.13)	0.6135
AIS A	2 (5.71)	3 (7.32)	16 (53.33)	<.0001
FES	20 (55.56)	20 (47.62)	16 (50)	0.7774

FIM, Functional Independence Measure; UTI, urinary tract infection; AIS A, ASIA Impairment Scale A (complete SCI); FES, functional electric stimulation.
*Mean (std) is presented for readability; †P value is calculated to test the distributions of variables among three groups overall based on Wilcoxon rank sum test, chi-square test, or Fisher's exact test. P value less than 0.05 is considered to have significant difference.

due to a UTI. One was unexpectedly transferred to a subacute rehabilitation facility due to insurance reasons.

Patient characteristics and clinical outcomes are presented in Table 1. The distribution of variables Age, Days Since Injury, Admission FIM motor, Admission FIM Cognitive, Discharge FIM Cognitive, and AIS A, are significantly different among the three groups. Post-hoc tests with Bonferroni correction further show that the differences are only between tetraplegia and paraplegia, not between upper and lower tetraplegia.

Patients were generally admitted to rehabilitation within 3 weeks of their injury. Sixty four percent of the tSCI patients (70) acquired a UTI during their admission. Demographic, clinical characteristics, and outcomes of patients who acquired a UTI during their inpatient rehabilitation stay were compared to the patients who did not acquire a UTI (Table 2). There were no differences in age, sex, days since injury, percentage of tetraplegia versus paraplegia, FIM cognition scores, all other infections, development of pressure ulcers, and VTE between the groups. There was also no differences in the severity of injury between the groups, based on the frequency of the most severe spinal cord injury, American Spinal Injury Association (ASIA) Impairment Scale (AIS) A, described as a complete SCI.

Those that had acquired a UTI during acute rehabilitation had lower median admission FIM motor (13 vs 27, $P < 0.0001$), admission FIM bladder (1 vs 3, $P < 0.0001$), discharge FIM motor (41 vs 65, $P < 0.0001$), discharge FIM bladder (4.5 vs 6, $P = 0.0002$), and gain FIM motor (22 v 26, $P = 0.007$) scores compared to the No UTI group. The UTI group also had a lower FIM efficiency (0.83 vs 1.83, $P < 0.0001$). The median length of stay (LOS) in those with a UTI was nearly double (31 vs 16, $P < 0.0001$) of those with No UTI. Those with an acquired UTI had a significantly larger mean of indwelling catheters days (7.81 v 1.28, $P < 0.0001$). Additionally, a substantially higher proportion of patients in the UTI group received FES leg cycle ergometry compared to the No UTI group (63% v 30%, $P = 0.0001$).

From Table 2, we can see that the gain FIM motor, gain FIM total, and FIM efficiency were significantly different between the two groups. Since the gain FIM total is the sum of the gain FIM motor and gain FIM cognitive, the latter of which was not significant, and since the FIM efficiency is based on LOS while LOS can be arbitrary (i.e. not necessarily based on FIM scores but discharge setting, social support, insurance coverage, etc.), we chose the gain FIM motor as the outcome. In the univariate analysis, among all candidate

Table 2 Patient characteristics and functional outcomes for UTI and no UTI groups.

	UTI n = 70	No UTI n = 40	
	Median (IQR)		P value†
Age	59 (38)	58.5 (37.5)	0.835
Days Since Injury	15 (11)	13 (10)	0.331
Indwelling Catheter Days*	7.81 (13.67)	1.28 (5.27)	**< 0.0001**
Admission FIM Motor	13 (11)	27 (20.5)	**< 0.0001**
Admission FIM Cognitive	25 (8)	25 (5.5)	0.158
Discharge FIM Motor	41 (36)	65 (16.5)	**< 0.0001**
Discharge FIM Cognitive	31 (7)	31 (5)	0.353
Gain FIM Motor	22 (23)	26 (19)	**0.007**
Gain FIM Cognitive	6 (6)	4 (7)	0.274
Gain FIM Total	26 (24)	32 (22.5)	**0.022**
Admission FIM bladder	1 (0)	3 (4)	**< 0.0001**
Discharge FIM bladder	4.5 (4)	6 (2)	**0.0002**
Change FIM bladder	2 (4)	2 (4)	0.472
FIM Efficiency	0.83 (1.06)	1.83 (2.30)	**< 0.0001**
Length of Stay (Days)	31 (13)	16 (13)	**< 0.0001**
	Frequency (%)		P value
FES	44 (62.86)	12(30)	**0.0001**
Male	48 (68.57)	32 (80)	0.195
AIS A	16 (23.19)	5 (13.51)	0.234
Tetraplegia	50 (71.43)	28 (70)	0.874
Other Infections	16 (22.86)	4 (10)	0.093
Pressure Ulcers	3 (4.29)	3 (7.5)	0.475
Venous Thromboembolism	3 (4.29)	1 (2.50)	1

FIM, Functional Independence Measure; FES, Functional Electric Stimulation; AIS A, ASIA Impairment Scale A (complete SCI).
*Mean (std) is presented for readability.
†P value is calculated based on Wilcoxon rank sum test, chi-square test, or Fisher's exact test. P value less than 0.05 is considered to have significant difference.

variables mentioned above, UTI, admission FIM motor, and age have P values less than 0.1, and entered the final multivariable linear regression model (Table 3). After controlling for age and admission FIM motor, UTI still showed a significant negative association with gain FIM motor (P = 0.012). On average, the gain FIM motor score is –8.84 (95% CI: [–15.62, –2.06]) lower in patients with UTI than in patients without UTI.

Subgroup analyses of those that received FES are presented in Table 4. Half of the group received FES (n = 56). There were no statistical differences in age, sex, days since injury, percentage of tetraplegia versus paraplegia, severity of injury (AIS A), or FIM cognition scores between patients who received FES and who did not, in either UTI subgroup (UTI v No UTI). As previously mentioned, there were more patients who received FES in the UTI group (63% v 30%, P = 0.0001). The FES group was more impaired at admission according to admission FIM Motor scores in both UTI subgroups.

Table 3 multivariable regression model for Gain FIM Motor.

Parameter	Estimate	Standard Error	P value
Intercept	36.62	6.72	< 0.0001
UTI	–8.84	3.46	**0.012**
Admission FIM Motor	–0.01	0.15	0.947
Age	–0.12	0.07	0.073

Some patients who acquired a UTI had more than one occurrence (34%). Subgroup analysis of the variables that were found to be significantly associated with the UTI group as a whole showed that only the length of stay was significantly longer in those with more than one UTI (Table 5).

Discussion

This is the first study evaluating the functional outcomes of tSCI patients associated with acquired UTIs in the acute rehabilitation setting. Based on an extensive literature review and recognizing the negative association of UTIs on functional outcomes in other neurologically impaired populations, the hypothesis was that a UTI acquired during inpatient acute rehabilitation for traumatic SCI would be associated with lower FIM motor score gains. There was a significant association with UTI and lower gain in FIM motor scores (–8.84, 95% CI: [–15.62, –2.06]) in patients with UTI than in patients without UTI. There was also a significant association between UTIs and lower admission FIM motor scores, lower discharge FIM motor scores, lower FIM efficiency, and nearly double lengths of stay.

These findings support the recent study by Kopp *et al.* which looked at the functional outcomes in SCI patients in those with acquired infections in the hospital, using 10 years of Model Systems data and screening 3,834 patients.[16] They concluded that hospital acquired pneumonia and wound infections are predictive of propagated disability and mortality after SCI. Of note, FIM motor gain was lower (–7.4 points, 95% CI: [–11.5, –3.3]) up to 5 years after SCI in those with pneumonia and wound infection.

As with other neurologic disorders, lower admission FIM scores are predictive of lower discharge FIM scores.[17] Data from the SCI Model Systems National Database also supports this generality that lower FIM admission motor scores yield lower discharge scores.[18] However, the results presented also show that lower FIM scores are associated with UTIs, including lower FIM admission, gain, and discharge motor scores. The relationship with FIM scores and UTI were unlike the findings in the Abdul-Sattar study.[13] One explanation for this association may be that those with greater

Table 4 Outcomes based on presence of acquired UTI and exposure to FES.

Variable	UTI			No UTI		
	FES n = 44	No FES n = 26		FES n = 12	No FES n = 28	
	Median (IQR)		P value†	Median (IQR)		P value†
Age	56 (34)	67.5 (40)	0.208	58 (47.5)	59.5 (33.5)	0.51
Days Since Injury	14.5 (14.5)	15 (11)	0.88	13 (14)	12.5 (10)	0.736
Indwelling Catheter Days*	8.59 (12.76)	6.50 (15.27)	**0.046**	3.25 (9.14)	0.43 (1.89)	0.086
Admission FIM Motor	12 (8)	17.5 (14)	**0.015**	21.5 (15)	30.5 (20)	**0.004**
Admission FIM Cognitive	24 (7)	25 (9)	0.338	27 (4.5)	25 (7)	0.279
Discharge FIM Motor	34 (35)	48 (27)	0.112	55.5 (22)	67.5 (11.5)	0.047
Discharge FIM Cognitive	31.5 (7)	29 (7)	0.724	30.5 (5)	32 (6.5)	1
Gain FIM Motor	18 (23.5)	25 (14)	0.285	26.5 (32.5)	26 (17)	0.814
Gain FIM Cognitive	6.5 (5)	4 (6)	0.090	3.5 (6.5)	5 (6.5)	0.499
Gain FIM Total	22 (22.5)	29 (14)	0.394	27.5 (37.5)	33 (19.5)	0.942
FIM Efficiency	0.69 (0.81)	1.07 (1.15)	0.108	1.20 (1.38)	2.19 (2.46)	**0.037**
Admission FIM bladder	1 (0)	1 (0)	0.069	1 (0)	5 (4)	0.02
Discharge FIM bladder	2 (4)	5 (3)	**0.037**	5.5 (2)	7 (2)	0.142
Change FIM bladder	1 (4)	4 (5)	0.088	3.5 (5)	2 (3)	0.173
Length of Stay (Days)	34 (12.5)	28 (15)	**0.026**	28 (15.5)	14.5 (11.5)	**0.003**
	Frequency (%)		P value	Frequency (%)		P value
Male	32 (72.73)	16 (61.54)	0.33	9 (75)	23 (82.14)	0.605
AIS A	11 (25.58)	5 (19.23)	0.545	2 (20)	3 (11.11)	0.597
Tetraplegia	32 (72.73)	18 (69.23)	0.754	8 (66.67)	20 (71.43)	1
Other Infections	9 (20.45)	7 (26.92)	0.534	1 (8.33)	3 (10.71)	1
Pressure Ulcers	1 (2.27)	2 (7.69)	0.551	0 (0)	3 (10.71)	0.541
Venous Thromboembolism	2 (4.55)	1 (3.85)	1	0 (0)	1 (3.57)	1
UTI number >1	15 (34.09)	9 (34.62)	0.964			

FIM, Functional Independence Measure; FES, Functional Electric Stimulation; AIS A, ASIA Impairment Scale A (complete SCI).
*Mean (std) is presented for readability.
†P value is calculated based on Wilcoxon rank sum test, chi-square test, or Fisher's exact test. P value less than 0.05 is considered to have significant difference.

impairments are at higher risk for UTIs. In the acute phase of injury, it has been documented that the immune system of the SCI patient is compromised, increasing the risk of infection.[19] In a recent publication, a mouse model of spinal cord injury-induced immune deficiency syndrome (SCI-IDS) demonstrated an injury level dependent dysfunction.[20] Although we did not see a significant relationship with UTI and injury level (upper/ lower tetraplegia versus paraplegia) or even complete versus incomplete SCI, it is plausible that those with lower FIM scores had a greater degree of SCI-IDS which increases the risk of UTI. Although FIM scores are not designed to describe the severity of SCI, FIM scores correlate well with both neurologic levels of injury and AIS grades. In other words, since the severity of SCI (lower FIM scores) may be related to the severity of SCI-IDS, and the UTI group had lower FIM scores and more indwelling catheter days, it remains unclear whether the incidence of UTI in SCI is related more to SCI-IDS versus bladder management methods. A randomized control trial of acute SCI bladder management would be required to properly test this hypothesis.

Indwelling catheter days were associated to both UTI and lower FIM motor scores. Esclarín de Ruz *et al.* has reported an odds ratio of nearly 8 in acquiring a UTI with an indwelling transurethral catheter in SCI.[21] This relationship of indwelling catheterization was also apparent in our data, making it rationale to eliminate indwelling catheter days, rather than UTI, from our

Table 5 Subgroup analyses of number of UTI compared to outcome variables significant in UTI group.

Variable	Indwelling Catheter Days Mean (Std)	Gain FIM Motor Median (IQR)	Length of Stay Median (IQR)	FES Number (%)
No UTI (n = 40)	1.28 (5.27)	26 (19)	16 (13)	12 (30)
UTI = 1 (n = 46)	6.57 (12.37)	22 (24)	29 (14)	29 (63.04)
UTI >1 (n = 24)	10.21 (15.89)	21 (25.5)	35.5 (21.5)	15 (62.5)
P value (UTI = 1 vs UTI > 1)	0.498	0.567	**0.003**	0.964

FIM regression model. Another explanation for the relationship of indwelling catheter days to FIM motor scores is that the presence of an indwelling catheter, per FIM scoring instructions, lowers the FIM motor score by lowering the FIM bladder scores. There were no differences in FIM bladder scores between tetraplegia and paraplegia groups.

The length of stay was nearly double in those with a UTI. In acute rehabilitation, length of stay is impacted by a number of different variables, including functional ability, medical status, psychosocial and family support, discharge setting, and insurance. It is difficult to determine whether it was the UTI, the diminished functional gains, or the other variables that increased the length of stay.

In a large stroke inpatient rehabilitation prospective study, the presence of an indwelling urinary catheter was not only associated with longer lengths of stay, but with more medical complications.[22] Our post-hoc sub group analyses were significant for increased lengths of stay when there was more than 1 UTI, without significant differences found in the other associations with the UTI group, including indwelling catheter days. Our findings suggest that it is more likely the repeated UTI versus the indwelling catheter that increases the lengths of stay.

The use of a FES was a confounding variable that we believed could impact functional gains and perhaps even morbidity and length of stay. FIM outcomes were not significantly impacted by the use of FES (Table 4). However, UTI subgroup analyses by FES showed a tendency to improve gain FIM motor associated with FES, although not statistically significant. The significantly decreased FIM gains found in the UTI group (Table 2) were no longer present with subgroup analyses based on the use of FES. The power of these calculations are limited, with small group sizes ranging from 12–44.

Limitations

The following limitations should be considered when interpreting these results. In this retrospective study, the data was not designed to test the hypothesis that UTIs are associated with lower FIM motor outcomes in tSCI acute rehabilitation. Association with risk factors for UTIs, including detailed analysis of frequency of intermittent catheterization, catheterization performed by staff, self, or caregiver, was attempted but unreliable based upon the collected data. Furthermore, descriptors of the UTI were not collected, including UTI symptoms, blood and urine markers, organisms in the urine cultures, and the antibiotics used and duration of treatment. This information along with subjective descriptors of well-being during UTI may be able to quantify the severity of the UTI for correlations to FIM scores. Perhaps not all UTIs are the same.

Another limitation in this study was the distinct time points used in the groups. The 6 year retrospective study encompassed 3 years without FES being used, followed by the next 3 years when it was used as standard care. While checking for an admission UTI remained the same over that time period, the staff which manages the catheters was likely to have changed. There were no major nursing protocol changes in this time period. Also, because the definition and decision to treat UTI in SCI remains unclear, chart review by physician was necessary to determine if a UTI was being treated versus a positive urinalysis or culture. It was determined that antibiotic treatment was necessary for treatment of UTI in all cases and no exclusions were made based upon inappropriate UTI treatment. The data of duration, dosage, and type of antibiotic were not collected, nor were the organisms causing infection.

There are well-documented FIM score averages for inpatient rehabilitation in tSCI that differ significantly between levels and severity of injury.[17] This is most apparent in tetraplegia. We were able to divide the groups into upper tetraplegia (C1-4) and lower tetraplegia (C5-8) and did not find a significant difference in FIM scores. Future studies evaluating the impact of UTI based on FIM scores would require a neurologic level and AIS grade, rather than the categories provided in this study. Also, FIM items lack adequate sensitivity to detect changes associated with the return of function after SCI.[23] Future studies would need to incorporate more sensitive measures to change, such as the Spinal Cord Independence Measure III (SCIM III).

The use of FES could not be quantified. While all patients in the FES group had lower extremity cycle ergometry, many also had upper extremity FES ergometry, abdominal FES, or traditional physical and occupational therapy with FES triggered by the therapist. Also, the location of surface electrodes and the amount of electric stimulation could not be captured in this retrospective chart review. A prospective study designed to test the hypothesis of improved FIM motor gains with FES in acute SCI rehabilitation would need to include these data points.

Finally, generalizability of the results of this investigation are limited by the fact that this was a single center study and the patient referral patterns are likely unique to this facility. The median age of our population was 59 years old, nearly 20 years older than the national average age of traumatic SCI. This may account for the higher rates of UTIs in this cohort.

Conclusions

As observed in other neurologic populations, the occurrence of a UTI in tSCI is negatively associated with functional outcomes during acute inpatient rehabilitation. Further prospective studies should be performed to better understand the relationship between UTI and rehabilitation outcomes in SCI and to design efforts to mitigate their occurrence. Advanced technology such as FES ergometry may play a role to improve FIM motor gains during tSCI inpatient rehabilitation.

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